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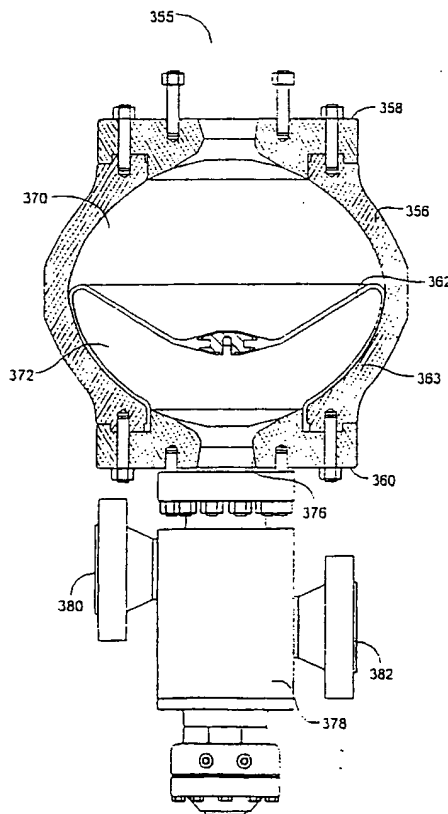
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(54) Title: SUBSEA MUD PUMP

(57) Abstract

A positive-displacement pump (102) includes multiple pumping elements (355, 356). Each pumping element having a pressure vessel (356) with a first (372) and a second (370) chamber and a separating member (362) disposed between the first (372) and second (370) chambers. The first (372) chambers and the second (370) chambers are hydraulically connected to receive and discharge fluid, wherein the separating members (362) move within the pressure vessels (356) in response to pressure differential between the first (372) and second (370) chambers. A valve assembly (378) having suction (380) and discharge (382) valves communicates with the first (372) chambers. The suction (380) and discharge (382) valves are operable to permit fluid to alternately flow into and out of the first (372) chambers. A hydraulic drive (420) alternately supplies hydraulic fluid to and withdraws hydraulic fluid from the second (370) chambers such that the fluid discharged from the first (372) chambers is free of pulsation.



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INTERNATIONAL SEARCH REPORT

International application No.
PCT/US99/06111

A. CLASSIFICATION OF SUBJECT MATTER

IPC(6) : F04B 17/00, 35/02, 43/10; E21B 15/02.

US CL : 417/395, 390, 521; 137/596.17; 251/129.07, 324, 282.

According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)

U.S. : 417/390, 392, 395, 401, 505, 521, 533; 137/596.17; 251/129.07, 324, 282.

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

Electronic data base consulted during the international search (name of data base and, where practicable, search terms used)
Please See Extra Sheet.

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X	US 2,703,055 A (Veth et al.) 01 March 1955, particularly see col. 1, lines 34-42 and col. 4, lines 58-70; generally see all.	1-2, 4-8, 11-13
X	US 4,755,111 A (Cocchi et al.) 05 July 1988, particularly see col. 4, lines 20-21; generally see all.	1-2, 4, 8, 11
X	US 4,705,462 A (Balembois) 10 November 1987, see Fig. 1 and col. 2, lines 3-11.	1-2, 12
X	US 5,924,448 A (West) 20 July 1999, see claims, abstract and related US application data.	1-2, 4, 11
X	US 4,832,005 A (Takamiya et al.) 23 May 1989, see col. 4, lines 34-45 and col. 4, lines 65-68.	1-2, 4, 11-13

☒ Further documents are listed in the continuation of Box C. ☐ See patent family annex.

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Date of the actual completion of the international search 14 SEPTEMBER 1999	Date of mailing of the international search report 19 OCT 1999
Name and mailing address of the ISA/US Commissioner of Patents and Trademarks Box PCT Washington, D.C. 20231 Facsimile No. (703) 305-3230	Authorized officer ROBERT Z. EVORA <i>Robert Z. Evora</i> Telephone No. (703) 308-0863

INTERNATIONAL SEARCH REPORT

 International application No.
 PCT/US99/06111

C (Continuation). DOCUMENTS CONSIDERED TO BE RELEVANT		
Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X	US 5,516,429 A (Snodgrass et al.) 14 May 1996, see col. 4, lines 38-46.	1-3, 11-13
X	US 4,523,901 A (Schippers et al.) 18 June 1985, see Figures.	1-2, 4, 8, 11
X	US 4,611,578 A (Heimes) 16 September 1986, see Figures and col. 8, lines 20-44.	1-2
X	US 2,419,993 A (Green et al.) 06 May 1947, see generally all.	1-2
Y	US 5,622,482 A (Lee) 22 April 1997, see abstract.	3
Y	US 5,558,506 A (Simmons et al.) 24 September 1996, see abstract.	3
Y	US 2,723,681 A (MacGlashan, Jr. et al.) 15 November 1955, see Figures and description generally.	8-9
Y	US 2,854,998 A (MacGlashan, Jr., et al.) 07 October 1958, see Figures and col. 2, lines 32-38.	8-10
Y	US 5,443,241 A (Odaira et al.) 22 August 1995, see Figure 1.	8-9
Y	US 5,263,514 A (Reeves) 23 November 1993, see Figure 1.	8-9
Y	US 5,297,777 A (Yie) 29 March 1994, see Figure 4d and col. 8, lines 49-68.	8-10
Y	US 4,632,358 A (Orth et al.) 30 December 1986, see Figures 1-2 and col. 5, lines 40-46.	8-10
Y	US 5,149,055 A (Huber et al.) 22 September 1992, see Figure 1.	8-9
Y	US 3,047,018 A (Lucien) 31 July 1962, see Figures.	10
X	US 5,480,292 A (Chevallier) 02 January 1996, see generally all.	1-2

INTERNATIONAL SEARCH REPORT

International application No.

PCT/US99/06111

B. FIELDS SEARCHED

Electronic data bases consulted (Name of data base and where practicable terms used):

APS, EAST:

search terms: pump, diaphragm, piston, hydraulic, subsea, mud, fluid, liquid, pulse, pulsation, reduce, valve, booster, positive, displacement, control, reverse flow, actuator, pressure, plunger, ribs, position, location, pressure sensor.